AN EVALUATION OF COST FACTORS IN THE PRODUCTION AND HARVESTING OF POTATOES

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AN EVALUATION OF COST FACTORS IN THE PRODUCTION AND HARVESTING OF POTATOES

By G. W. French, *agricultural engineer, Agricultural Research Service*

INTRODUCTION

The total costs of potato production and harvesting are widely variable among the major potato producing areas and among growers within an area. Some of the factors that modify production costs are indigenous to specific areas, such as soil type, climate, land values, and prevailing wage rates. Other factors that modify production and harvesting costs are related to the organization and management of the potato producing enterprise.

The total acreage of potatoes and other crops in an enterprise has an important bearing upon potato production costs. The size of the machines, travel speed, and operating efficiency modify costs. It would be extremely difficult to find two growers with the same costs for each operation. The individual grower should carefully analyze his own potato production and harvesting costs within the context of his total farming enterprise. This publication was designed to help him do that.

The objective of the analysis presented here is to provide a guide for estimating these costs. Each of the several functions required in potato production and harvesting is separately analyzed for a range of performance rates with machines of different sizes used on annual acreages of 80 to 640 acres. Selected values can be taken from the analysis of these functions and combined to arrive at a figure for total production and harvesting costs.

Field observations included measurement of performance rates to insure realistic ranges for cost estimates. While these observations were made in the Red River Valley of Minnesota-North Dakota, it is believed that the ranges of work rates analyzed are sufficiently broad to be applicable to other potato growing areas.

Another objective of this study is the determination of the cost of individual functions to give some indication where research might be profitable. It is not implied that all comparatively high cost operations can be substantially reduced, and, obviously, research aimed at reducing the cost of an operation already in a low cost range carries no potential for a large reduction in overall costs.

METHOD OF COST ESTIMATION

The costs involved in potato production fall into two categories, fixed and operating costs. These are classified as follows for the purpose of this study:

- Fixed Costs
  - Land rent
  - Machinery
    - Depreciation
    - Interest
    - Taxes
    - Housing
    - Insurance
- Operating Costs
  - Materials
    - Seed potatoes
    - Fertilizer
    - Insecticides, fungicides, and herbicides
  - Machinery
    - Maintenance and repairs
    - Fuel and lubricants
  - Labor

Most potato growers also produce other crops, and potato production costs for an individual grower are affected by the type and size of the total farming operation. Approximately one-half of the investment for equipment used in potato production is for general purpose machines, such as tractors, trucks, plows, and tillage implements which may be used on other crops (*5*).[1] Therefore, the fixed (ownership) cost per acre is independent of the number of acres of potatoes produced. The fixed cost per acre for specialized machinery, such as potato harvesters, planters, and seed potato cutters, is based on the potato acreage only.

In this study, repairs are considered as an operating cost based on a specified percentage of the new cost per 100 hours of use. For simplicity, repair costs are reduced to a per-acre basis. Where

[1] Italic numbers in parentheses refer to Literature Cited, p. 21.

published data on repair costs are available, these figures are used. For that matter, repair costs are widely variable, being influenced by quality of maintenance, soil type, and skill of the operator. With potato diggers and harvesters, the soil type can be an extremely important factor in repair costs. Housing may also modify repair costs. Not all machinery is placed under cover when not in use, but it is not illogical to include a charge for housing inasmuch as the repair costs may be increased by the lack of housing.

The hourly cost of labor is considered as independent of the size of potato acreage. The cost of labor per acre for a given operation is variable, however, because of differences in capacity of the machines used. It is assumed that labor in the required amount is available for the performance of each operation. In addition to labor for field operations, labor is required for repairs on the machine used. This is not shown as a separate item charged to field operations because repair costs shown include both labor and parts.

Many small but essential items, such as wrenches and other hand tools, are necessary. These are not specifically named; they are included in the repair and maintenance costs.

The number of days available for a given operation is probably the most important single factor in selection of equipment. If this is the only criterion, then equipment of the size and amount to give the most favorable combination of fixed (ownership) and operating costs is indicated. However, timeliness is a factor that also should be considered. It may be advantageous in certain situations to incur higher fixed costs which can be offset by increased yield or better quality due to timely performance of an operation.

Field conditions affect not only repair costs, but also operating capacities of machines. This is particularly true of harvesters. Not only is the acres-per-hour rate related to field conditions, but the number of workers required may be greatly increased by adverse field conditions. Field conditions that limit machine capacities, such as soil type, slope, stones, may be inherent to the locality. Prevailing seasonal climatic conditions also may greatly affect harvesting rates. Limited field observations of commercial operations were made to insure that the ranges of machine capacities used are reasonable. This is not to imply that all potato growers will find machine capacities to be within the limits used, but it is believed that most will be within these limits.

To compare alternative cultural practices and harvesting methods is not one of the objectives of this study. The practices analyzed are in widespread use, but there are no implications of superiority to alternative practices that are not included in this cost analysis. For instance, insecticides and fungicides, which are universally used, may be applied either in dust form or as a liquid spray. Spraying has been selected for analysis without any implication of superiority to dust application.

Mechanized harvesting of the potato crop is subject to notable variations in technique and types of auxiliary equipment used. The analysis of harvesting costs, however, is confined to two-row direct operation wherein all the harvesting functions (excavation, elevation, separation, and conveyance to hopper-bottom truck box) are accomplished in one operation.

MACHINERY COSTS [2]

Fixed costs

The fixed, or ownership, costs of all equipment are calculated on a uniform basis as follows:

- Depreciation is based on an estimated life of the machine and the new cost less 10 percent for salvage value.
- Interest is 6.5 percent of average value.
- Taxes are 2 percent of average value.
- Housing is 1.6 percent of average value.
- Insurance is 0.42 percent of average value.

Annual depreciation rates vary, depending on the estimated life of the machine. Average value is one-half of the new cost plus salvage value. Throughout this study, the salvage value is considered to be 10 percent of the new cost; thus, the average value becomes 55 percent of the new cost. Other fixed costs (interest, taxes, housing, insurance) are the same for all equipment and amount to 5.78 percent of the new cost. This percentage is used throughout this analysis. For the application of any other values, the following general formula can be used for total annual fixed (ownership) costs.

$$FC=\frac{N-S}{Y}+\frac{(R+T+H+I)(N+S)}{2}$$

FC=annual fixed cost; N=new cost; S=salvage value;
Y=assumed life in years; R=interest rate; T=tax rate;
H=housing; I=insurance.

As the above formula indicates, a straight-line method of depreciation is used. For calculating the fixed cost of a machine, the straight-line method is the most practical and most commonly

[2] "Machinery" as used here refers to all equipment used in the production and harvesting of potatoes except tractors and trucks.

used (*2*). It gives a constant charge for depreciation throughout the life of the machine.

Calculation of depreciation costs requires an estimate of the useful life of a machine. Theoretically, the life of a machine could be extended indefinitely if repair parts are available and worn parts are replaced as required. However, this may not necessarily be economical. Obsolescence is frequently an important factor which leads to replacement of machines before they are worn out. Machine life depends on quality of maintenance, field conditions, annual use, and other factors; therefore, an estimate of useful life is necessarily an approximation that will not fit all situations. Data from *Agricultural Engineers Yearbook* (*1*) have been extensively used as a guide in determination of machinery costs.

Operating costs

Included in operating costs are repairs, maintenance, fuel, lubricants, and labor. Repair costs, on the basis of annual usage, are estimated as a percentage of the new cost of the machine per 100 hours of use. Where applicable, data from *Agricultural Engineers Yearbook* (*1*) are used. For some types of machines used only for potatoes, there are few or no data available. Estimated repair costs were arrived at by a combination of personal observations and published data for machines that might be considered somewhat similar in respect to repair costs. Labor for installing repair parts, lubrication of the machine, and other maintenance are included in the estimated costs for repairs and maintenance.

Repair costs have been converted from an hourly basis to a per-acre basis for an average rate of performance, and the same repair cost per acre is used for all rates of operation. This is logical because an increased rate of operation would result in a lower per-acre repair cost if the estimated cost were maintained on an hourly basis.

All labor is charged at $1.25 per hour. It is recognized that management and supervision are necessary, but the costs of these functions are not included.

TRACTOR COSTS

Tractors required for field operations in potato production are generally used for other purposes. The fixed costs charged to potato production depend on the percentage of the total use that is devoted to the potato crop. This percentage is widely variable among potato growers. For the purpose of this analysis, it is assumed that tractors will be used 800 hours per year and that the life of the tractor is 15 years, or 12,000 hours (*2*). Depreciation is based on a 15-year life and a salvage value of 10 percent of the new cost. For each field operation, a fixed hourly tractor charge is used and is handled as an operating cost.

Tractors of different sizes are required to provide efficient machine and tractor combinations for potato acreage of varying size. Also, various operations require tractors of different sizes.

To facilitate the computation of tractor costs five hypothetical tractors are used. The specifications of each size are based on Nebraska Tractor Test data on power to weight ratios. The capacity of each size of tractor is established in accordance with the following limitations:

- The power output of the engine is considered to be 75 percent of maximum.
- The power available at the drawbar is based on a traction and transmission coefficient of 0.65.
- Wheel weights, or other added ballast, may equal 10 percent of the tractor weight.
- Maximum drawbar pull, without excessive wheel slippage, is 48 percent of the weight of the tractor plus added ballast.

The specifications of the tractors considered in this analysis are listed in table 1. All are wheel-type units with gasoline engines.

The cost per hour for tractor use is the sum of fixed and operating costs. Obviously, the fixed cost charge per hour of use is inversely proportional to the number of hours of use per year. Fuel, oil, repairs, and maintenance, which are proportional to use, constitute operating costs. Operating cost per hour is independent of the number of hours used per year. Table 2 shows operating costs and hourly fixed costs for the tractors described in table 1.

TABLE 1.—*Specifications and annual fixed costs of tractors used in producing and harvesting potatoes*

Tractor	Cost of machine when new	Specifications				Annual fixed costs [1]		
		Weight (lb.)	Power output (75 percent of maximum horsepower)	Effective drawbar horsepower	Maximum effective draft (lb.)	Depreciation	Interest, taxes, housing, insurance	Total annual fixed costs
A	$2,643	3,515	26.70	17.35	1,670	$158.58	$152.76	$311.34
B	3,561	4,735	35.51	23.11	2,250	213.66	205.82	419.48
C	4,749	6,315	45.06	29.30	3,000	284.94	274.49	559.43
D	5,936	7,893	55.92	36.35	3,750	356.16	343.10	699.26
E	7,835	10,030	68.75	44.69	4,800	470.12	452.87	922.99

[1] Depreciation is based on 15-year life and salvage value of 10 percent of new cost. Interest, taxes, housing, and insurance constitute an annual cost equal to 5.78 percent of new cost.

TABLE 2.—*Cost per hour of using tractors in potato production*

Tractor [1]	Fuel used per hour [2] (gal.)	Operating costs [3]		Fixed cost based on [1]—		Total cost based on [1]—	
		Fuel and oil	Repair and maintenance	550 hours use per year	800 hours use per year	550 hours use per year	800 hours use per year
A	3.12	$0.79	$0.26	$0.57	$0.39	$1.62	$1.44
B	4.16	1.05	.36	.76	.52	2.17	1.93
C	5.27	1.33	.47	1.02	.70	2.82	2.50
D	6.54	1.65	.59	1.27	.88	3.51	3.12
E	7.09	1.79	.78	1.67	1.15	4.24	3.72

[1] See table 1 for specifications of tractors and annual fixed costs.
[2] 1 gallon of gasoline used per 8.5 hp.-hr.
[3] Cost of gasoline is 22 cents a gallon; cost of oil is 15 percent of cost of gasoline; and repairs and maintenance are 0.01 percent of the cost of new machine.

TRUCK COSTS

One or more trucks are required for planting, crop spraying, and harvesting. As with tractors, the trucks are presumed to be used for purposes other than potato production and harvesting. The fixed costs of trucks are computed as for other equipment. The fixed costs, based on 600 hours of use per year, are combined with the truck operating costs to obtain a total hourly cost for use of a truck. In the individual field operations, the total truck cost is considered as an operating cost. The trucks used to haul seed potatoes and fertilizer to the field are traveling only intermittently, and, consequently, the actual hourly truck operating costs are less for planting than for harvesting. When used in harvesting, the truck is traveling most of the time.

The fixed costs for the hopper-bottom box are computed on a per-acre basis. It is assumed the truck boxes will be used only in potato production. Therefore, the fixed cost per acre is independent of the number of hours or days used on a given acreage. The hopper-bottom truck box, although used primarily for harvesting, may also be used for handling cut seed potatoes. The total cost (fixed plus operating) is charged to harvesting. The operating cost (repairs) is estimated at 10 cents per acre.

A ½-ton or ¾-ton pickup truck is commonly used as a service vehicle in the various field operations. It is difficult to calculate precisely the cost to be charged for the use of this vehicle. If we assume that the pickup is not used exclusively in the potato enterprise, the cost could be comparatively minor. Instead of attempting to calculate the part of cost of the pickup chargeable to each operation, it is suggested that $0.50 to $1 per acre be added to the other annual costs.

Fixed costs for trucks, hopper-bottom boxes, and a flatbed are given in table 3. Estimated costs of a 2-ton truck when used in planting, spraying, and harvesting are shown in table 4.

TABLE 3.—*Fixed costs per hour and per acre for a 2-ton truck, pickup truck, flatbed, and hopper-bottom box used in potato production*

Equipment	Cost of machine when new	Annual cost	Cost per hour for annual use of—			Cost per acre for use on—			
			400 hours	600 hours	800 hours	80 acres	160 acres	320 acres	640 acres
2-ton truck	$4,000	$531	$1.33	$0.88	$0.66				
½-ton pickup	2,600	345	.86	.58	.43				
Flatbed	300	44	.11	.07	.05				
Hopper-bottom box	700	103				$1.28	$0.64	$0.32	$0.16
Do	900	133				1.66	.83	.42	.21

TABLE 4.—*Operating cost per hour for a 2-ton truck used in potato production* [1]

Operation	Fuel and lubrication	Tires and repairs	Total
Planting	$0.14	$0.06	$0.20
Spraying	.28	.12	.40
Harvesting	1.38	.63	2.01

[1] Operating cost per hour is based on the time the truck is committed to a particular use.

PLOWING COSTS

Plowing is the primary tillage method used for 70 percent of the potato acreage in the Red River Valley (*5*). Owing to wide variations in resistance of the soil, costs of plowing are variable. Plow draft is affected by soil type, soil moisture, and cultural practices. Plow design and adjustments also affect draft. The effects of soil differences on plow draft is illustrated in table 5. Normal draft may range from 5 pounds to 12 pounds per square inch of cross-section of furrow (*7*).

Obviously, with a plow of a given size, a smaller tractor can be used in lighter soil than in heavy soil. For this reason, the tractors specified in this study are not classified as 3-plow, 4-plow, etc. According to Nebraska Tractor Test data, the ratings formerly applied to tractors were apparently based on 14-inch bottoms plowing to a depth of 6 inches in soil having a draft of 6 pounds per square inch (p.s.i.) of furrow section (assuming very favorable tractive-efficiency conditions) (*8*).

Table 6 shows plow costs based on a wear-out life of 2,500 hours. Depreciation costs are calculated for 15, 12, and 8 years of life, wherein it is assumed that annual use is such that total

TABLE 5.—*Relation of soil resistance to horsepower-hours per acre and to plow draft* [1]

Soil resistance	Draft per foot of width (lb.)	Draft (lb.)				Hp.-hr. per acre
		3-bottom plow	4-bottom plow	5-bottom plow	6-bottom plow	
4.5 p.s.i.	324	1,134	1,512	1,890	2,268	7.12
7.0 p.s.i.	504	1,764	2,352	2,940	3,528	11.09
11.0 p.s.i.	792	2,772	3,696	4,620	5,544	17.42
13.4 p.s.i.	965	3,377	4,502	5,629	6,755	21.23

[1] Draft based on 14-inch plow bottoms and 6-inch plowing depth.

TABLE 6.—*Fixed costs for moldboard plows used in potato production*

Type of plow	Cost of machine when new	RTHI [1] cost per year	Depreciation cost per year based on life of—			Fixed cost per hour of use [2] based on—		
			15 years	12 years	8 years	167 hours per year	208 hours per year	312 hours per year
3-bottom	$560	$32. 36	$33. 60	$42. 00	$63. 00	$0. 39	$0. 36	$0. 31
4-bottom	700	40. 46	42. 00	52. 50	78. 75	. 49	. 45	. 38
5-bottom	950	54. 91	57. 00	71. 25	106. 87	. 67	. 61	. 52
6-bottom	1, 200	69. 36	72. 00	90. 00	135. 00	. 85	. 77	. 65

[1] Interest, taxes, housing, and insurance amount to 5.78 percent of new cost.
[2] Hours of use per year determines years of life of plow.

use amounts to 2,500 hours. Repairs are considered to be 7 percent of the new cost per 100 hours of use (*1*). The direct application of this formula results in an apparent increase in repair costs if plow speed is reduced, so repair costs have been converted to a per-acre basis with an assumed operating speed of 4.5 m.p.h. and an operating efficiency of 0.82. This results in an average repair cost of 25 cents per acre.

The cost of plowing includes fixed costs for all equipment, operating costs, and labor (table 7). The fixed cost per hour of use is shown in table 6. The plow operating costs are considered to be $0.25 per acre. The hourly tractor costs, including fuel, are shown in table 2. Certain assumptions were made in computing the costs. It is assumed that the drawbar power indicated in table 1 will be fully utilized, unless full utilization of the available power would result in a speed significantly higher than 5 m.p.h.

TABLE 7.—*Cost per acre for plowing* [1]

Plow	Light soil (4.5 p.s.i.)					Medium soil (7 p.s.i.)				
	Draft (lb.)	Tractor	Speed (m.p.h.)	Acres per hour	Cost per acre	Draft (lb.)	Tractor	Speed (m.p.h.)	Acres per hour	Cost per acre
3-bottom	1, 134	A	5. 0	1. 74	$2. 02	1, 764	B	4. 91	1. 71	$2. 34
4-bottom	1, 512	A	4. 30	1. 99	1. 85	2, 352	C	4. 67	2. 16	2. 21
5-bottom	1, 890	B	4. 58	2. 65	1. 70	2, 940	C	3. 74	2. 17	2. 29
6-bottom	2, 268	C	4. 63	3. 24	1. 67	3, 528	D	3. 86	2. 69	2. 20
6-bottom	2, 268	D	5. 0	3. 50	1. 74	3, 528	E	4. 75	3. 32	2. 13
Plow	Heavy soil (11 p.s.i.)					Extra heavy soil (13.4 p.s.i.)				
3-bottom	2, 772	C	3. 96	1. 38	3. 25	3, 377	D	4. 04	1. 40	3. 65
4-bottom	3, 696	D	3. 68	1. 71	3. 09	4, 502	E	3. 72	1. 74	3. 64
4-bottom	3, 696	E	4. 53	2. 12	3. 03					
5-bottom	4, 620	E	3. 63	2. 12	3. 11					

[1] These costs are based on a plowing depth of 6 inches, tractor use of 800 hours per year (table 2), 14-inch plow bottoms, and plow life of 15 years (table 6). Repair costs are 25 cents per acre; operating efficiency, 82 percent; labor, $1.25 per hour.

SECONDARY PREPLANTING TILLAGE COSTS

Some type of seedbed preparation usually precedes planting when potatoes are planted on fall-plowed ground. Diverse implements are used, such as field cultivators, disk harrows, spike-tooth harrows, and spring-tooth harrows. Although the cost of a moderate amount of secondary preplanting tillage is relatively minor, research has indicated that there may be no benefit from preplanting tillage in the spring on some soil types (*3*). Costs of secondary preplanting tillage in this study are based on the use of field cultivators and spike-tooth harrows of several sizes.

Fixed costs of field cultivators and harrows are based on estimated life of 12 and 20 years, respectively. Wear-out life of both types of implements is considered to be 2,500 hours. If use is such that the machine is worn out in fewer years, only a modest reduction in fixed costs would be gained. This fact is illustrated in the analysis of fixed costs for moldboard plows (table 6).

Fixed costs for field cultivators and plows are calculated in the same manner as for tractors and plows, but the costs per hour are omitted from the table and the cost per acre is indicated. If these implements are used on other crops, the fixed costs charged to potato production would be based on the total acreage. For instance, the fixed cost per acre for a 10-ft. field cultivator is $1.16 (table 8) if used on 80 acres of potatoes only; if it is used on an additional 240 acres for other crops, then the fixed costs charged to the potato crop would be reduced to $0.29 per acre.

If an implement, such as a cultivator or a harrow, is used more than once on a given acreage, the fixed cost per acre charged to the crop would not be increased by successive use. For example, if a field cultivator used exclusively for potato production is used for primary tillage in the fall, and used again the following spring, the fixed costs would be divided between these two operations or charged to only one of them.

Operating costs (table 9) include labor, repairs, and charges for tractor use based on the costs per hour for tractor use in table 2. Repair costs are based on 4 percent of the new cost per 100 hours of use. This amounts to about 8 cents per acre for field cultivators and 3 cents for spike-tooth harrows.

TABLE 8.—*Fixed costs per acre for field cultivators and spike-tooth harrows used in potato production*

Machine and its width	Cost of implement when new	Annual fixed cost	Cost per acre based on annual use on—			
			80 acres	160 acres	320 acres	640 acres
Field cultivator:						
7 feet	$575	$76.36	$0.95	$0.48	$0.24	$0.12
10 feet	700	92.96	1.16	.58	.29	.15
13 feet	850	112.88	1.41	.71	.35	.18
Spike-tooth harrow:						
26 feet	625	64.25	.80	.40	.20	.10
37 feet	895	92.00	1.15	.58	.29	.14
47 feet	1,150	118.22	1.48	.74	.37	.18

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TABLE 9—*Operating costs for field cultivators and spike-tooth harrows used in potato production* [1]

Machine and its width	Tractor	Speed (m.p.h.)	Acres per hour	Costs per acre			
				Tractor	Labor	Repairs	Total
Field cultivator:							
10 feet	A	4.06	4.06	$0.35	$0.31	$0.08	$0.74
10 feet	B	5.41	5.41	.36	.23	.08	.67
13 feet	B	4.16	5.41	.36	.23	.08	.67
13 feet	C	5.28	6.86	.36	.18	.08	.62
2 x 10 feet	D	4.26	8.52	.37	.15	.08	.60
2 x 10 feet	E	5.24	10.48	.38	.12	.08	.58
Spike-tooth harrow:							
26 feet	A	4.17	10.8	.13	.12	.03	.28
26 feet	B	5.55	14.3	.14	.09	.03	.26
37 feet	B	3.85	14.3	.14	.09	.03	.26
37 feet	C	4.94	18.3	.14	.07	.03	.24
47 feet	C	3.90	18.3	.14	.07	.03	.24
47 feet	D	4.83	22.7	.14	.06	.03	.23
47 feet	E	5.94	27.9	.14	.05	.03	.22

[1] Capacity of machines and tractors is based on a draft of 160 and 60 lb. per foot of width for field cultivators and spike-tooth harrows, respectively. Acres per hour is based on full utilization of drawbar-horsepower (table 1) and operating efficiency of 82 percent.

SEED POTATO CUTTING COSTS

Some growers use "B" size seed potatoes planted whole and have no seed cutting costs. The "B" size seed currently available is probably a comparatively small percentage of the total amount of seed used; therefore, the cutting of seed potatoes constitutes a cost item in most potato growing operations.

Most seed potatoes are mechanically cut, either in a building on the farm, or in a track-side storage. A variety of machines are commercially available (*4*). But the characteristics of different types are not pertinent to this projection of seed potato cutting costs, which are based on specified machine prices, cutting capacities, annual use, and labor requirements. Fixed costs for seed potato cutters are listed in table 10.

The cut seed pieces may be subjected to either a liquid or dust treatment immediately after cutting. Treatment of seed is not a universal practice There is a diversity of equipment used for this purpose; it is commercially available or may be custom made. Usually, the methods used do not require additional workers, so the price of the material used constitutes the principal cost of treatment unless some elaborate equipment is used. The cost per acre for seed potato cutting and treating is modified by the planting rate and the material used. For the purpose of this analysis, the cost of seed treatment will be considered to be $1.95 per acre for material and $0.50 for equipment.

Seed potato cutting, treating, and planting are usually carried on simultaneously. In addition to mechanical cutters, treaters, and potato planters, some equipment is used that is primarily purchased for other uses. In this analysis, the seed

TABLE 10.—*Fixed costs of seed potato cutter*

Cost of new machine	Annual costs			Cost per acre based on—			
	Depreciation [1]	RTHI [2]	Total	80 acres	160 acres	320 acres	640 acres
$800	$60	$46.24	$106.24	$1.33	$0.66	$0.33	$0.17
$1,200	90	69.36	159.36	2.00	1.00	.50	.25
$3,300	247	190.74	437.74	5.47	2.73	1.37	.68

[1] Based on expected life of 12 years.
[2] Interest, taxes, housing, and insurance.

potatoes are mechanically cut and loaded with a bin loader into a hopper-bottom truck box. Since the bin loader and the hopper-bottom box are used much more extensively in harvesting, only operating costs of these items will be charged to planting.

For the system considered, three trucks are required. Two will carry hopper-bottom potato boxes for hauling seed. Since most of the time these trucks are either sitting at the seed potato cutting location or in the field, their operating costs are much lower than when used in harvesting. The third truck is needed to haul fertilizer, and its operating cost is also low.

Operating costs of cutting seed potatoes include labor costs, power, repairs, and maintenance for the seed potato cutter.

The number of workers used for seed potato cutting operations varies widely and depends, to a considerable extent, on the type of cutter used, the method of handling potatoes from storage to cutter, and the condition of the seed potatoes (excessively sprouted potatoes may cause difficulties that add to labor costs).

If cutting and planting are carried on simultaneously, a cutting rate greatly in excess of the planting rate results in intermittent performance of the cutting operation. For the purpose of this analysis, it is assumed that the rate of cutting seed potatoes approximates the planting rate. Costs are projected in table 11 for operations utilizing from one to four workers for rates of 20 to 60 cwt. per hour. This range of cutting rates approximates the range of seed requirements when 13 cwt. per acre are planted at rates of 1.5 acres to 4.5 acres per hour.

TABLE 11—*Operating costs for cutting seed potatoes*

Seed potatoes cut per hour	Labor cost per cwt.				Total operating costs per acre [1]			
	1 worker	2 workers	3 workers	4 workers	1 worker	2 workers	3 workers	4 workers
20 cwt	$0.06	$0.12	$0.19	$0.25	$1.09	$1.90	$2.71	$3.53
40 cwt	.03	.06	.09	.12	.64	1.05	1.45	1.86
60 cwt	.02	.04	.06	.08	.46	.73	1.01	1.28

[1] Cost per acre is based on a planting rate of 13 cwt. per acre. Added to labor costs is 1 cent per cwt. for power, repairs, and maintenance. Operating cost of binloader (32 cents per hour) is also included in per-acre cost of seed cutting (*6*).

PLANTING COSTS

The only major piece of equipment used exclusively in the planting operation is the potato planter itself. This implement is usually a 2-row or 4-row unit. Tillage operations performed before planting are not usually affected by the row spacing subsequently used. The planting rates, in terms of acres, are determined by row spacing, travel speed, and operating efficiency. Planting rates have been calculated for 38-inch row spacing. All the following operations are, therefore, based on 38-inch row spacing. Table 12 shows fixed costs for 2-row and 4-row potato planters.

TABLE 12.—*Fixed costs of potato planter*

Type of planter	Cost of new machine	Annual cost [1]	Cost per acre based on—			
			80 acres	160 acres	320 acres	640 acres
2-row	$1,450	$171	$2.13	$1.07	$0.53	$0.27
4-row	3,200	376	4.70	2.35	1.17	.59

[1] Estimated life of 15 years, or 2,500 hours.

Where cut seed potatoes are transported to the field in hopper-bottom truck boxes, some kind of conveyor is used to transfer the seed to the planter hopper (fig. 1). Sometimes a bin loader is moved to the field and used for this purpose. The power source may be an alternating current generator attached to the tractor or a small gasoline engine mounted on the bin loader. More commonly, a small custom-made conveyor is used, which is driven either by a small gasoline engine or from the power takeoff shaft of the truck transmission. This type of conveyor is designed so that it is easily transferable from one truck box to another. On the basis of $600 new cost and expected life of 15 years, the fixed cost is $70.68 per year. This amounts to 88, 44, 22, and 11 cents per acre, respectively, for acreages of 80, 160, 320, and 640.

In addition to the planter and transfer conveyor for seed potatoes, which are used only in the potato planting operation, one tractor, three trucks, two hopper-bottom truck boxes, and one flatbed are used. The tractor and truck costs (tables 2, 3, and 4) are considered as operating costs in table 13.

FIGURE 1.—A detachable conveyor for transferring cut seed from hopper-bottom box to the planter. The conveyor is driven by the truck engine.

TABLE 13.—*Costs per acre of labor and of operating machinery for planting potatoes*

Equipment used and speed of tractor	Acres planted per hour [1]	Operating costs per acre planted			
		Tractor	Truck	Labor	Total
2-row planter, size B tractor:					
3.0 m.p.h.	1.50	$1.29	$2.04	$1.67	$5.65
3.5 m.p.h.	1.74	1.11	1.82	1.44	5.02
4.0 m.p.h.	2.00	.97	1.63	1.25	4.50
4.5 m.p.h.	2.24	.86	1.50	1.12	4.13
4-row planter, size D tractor:					
3.0 m.p.h.	3.00	1.04	1.22	1.25	4.16
3.5 m.p.h.	3.48	.90	1.11	1.08	3.74
4.0 m.p.h.	4.00	.78	1.02	.94	3.39
4.5 m.p.h.	4.48	.70	.96	.84	3.15

[1] Acres per hour based on 38-inch row spacing and operating efficiency of 65 percent.

CROP MAINTENANCE COSTS

Crop maintenance includes all field treatments performed throughout the growing season. This usually includes going over once with a spike-tooth harrow or a spring tine weeder, three or four times with a row-crop cultivator, and spraying three or four times with fungicide and insecticide. The fixed costs of spike-tooth harrows are listed in table 8. Fixed costs of other crop maintenance equipment are shown in table 14. The tractor used and its travel speed affecting operating costs for a row-crop cultivator are shown in table 15.

Table 16 shows sprayer operating costs for different application rates. Travel speed and, consequently, operating costs are affected by the quantity of water used per acre. The amount of water required for complete coverage of the foliage depends on the size of the potato plants and on the characteristics of the sprayer. The spraying operation requires the use of a tractor to pull the sprayer, a truck and water tank to supply water, and a pump to transfer water from the supply tank to the sprayer tank.

TABLE 14.—*Fixed costs of equipment used in potato crop maintenance*

Kind and size of machine	Cost of new machine	Annual cost	Cost per acre based on—			
			80 acres	160 acres	320 acres	640 acres
Row-crop cultivator: [1]						
2-row	$405	$53. 78	$0. 67	$0. 34	$0. 17	$0. 08
4-row	855	113. 54	1. 42	. 71	. 35	. 18
Row-crop sprayer: [2]						
12-row	1, 250	184. 75	2. 32	1. 16	. 58	. 29
14-row	2, 050	303. 00	3. 76	1. 88	. 94	. 47
Tank, 1,000 gal	225	33. 25	. 40	. 20	. 10	. 05
Pump	150	22. 17	. 28	. 14	. 07	. 03

[1] Depreciation of cultivators based on 12 years' expected life.

[2] 12-row sprayer equipped with 200-gal. tank and 10-g.p.m. pump. 14-row sprayer has 400-gal. tank and 22-g.p.m. pump. Life of sprayer and auxiliary equipment considered to be 10 years.

TABLE 15.—*Operating costs of row-crop cultivators used in potato production*

Cultivator	Tractor	Speed (m.p.h.)	Acres per hour [1]	Cost per acre [2]		
				Tractor	Labor	Total
2-row	A	3. 5	2. 28	$0. 63	$0. 55	$1. 30
2-row	B	3. 5	2. 28	. 85	. 55	1. 52
2-row	A	5. 0	3. 26	. 57	. 38	1. 07
2-row	B	5. 0	3. 26	. 77	. 38	1. 15
4-row	C	3. 5	4. 30	. 58	. 29	. 99
4-row	C	5. 0	6. 14	. 53	. 20	. 85

[1] Acres per hour based on 38-inch row spacing.

[2] Operating efficiencies are 85 percent for 2-row cultivators and 80 percent for 4-row cultivators. Total operating cost includes 12 cents per acre for cultivator repairs and maintenance.

Repairs and maintenance costs for a sprayer are estimated to be 5 percent of the new cost per 100 hours of use. This constitutes the sprayer operating cost, as the power cost for driving the pump is included in the charge for tractor use. For the sprayers considered in this study, the repair costs amount to approximately $1 per 1,000 gallons of spray solution used. The repair cost per acre is computed on this basis in table 16. The travel speed is determined by the pump capacity, number of rows covered, and the gallons of water per acre. The highest practical speed is considered to be 5 m.p.h. If the pump capacity is greater than required for the application rate at 5 m.p.h., it is assumed that the bypass valve is adjusted to provide the desired application rate. The combined repair costs for the pump used to transfer water to the sprayer tank and for the tank itself is estimated to be $0.20 per 1,000 gallons.

Table 16 indicates equipment operating costs for spraying, but does not show costs of spray materials. The cost of spray materials exceeds the total fixed and operating costs if four applications are used. The first spray treatment is usually insecticide only; the second and third, insecticide plus fungicide; the fourth, fungicide only. The

TABLE 16.—*Equipment operating costs for spraying potato crop*

Equipment used, size of crew, and quantity of spray per acre	Gallons of spray per minute	Tractor speed (m.p.h.)	Acres sprayed per hour	Operating costs per acre [1]					
				Sprayer	Tank pump	Tractor	Truck	Labor	Total
12-row sprayer, tractor B, 2 men:									
15 gallons	5.75	5.0	14.9	$0.025	$0.01	$0.14	$0.09	$0.18	$0.46
25 gallons	9.60	5.0	14.9	.025	.01	.14	.09	.18	.47
35 gallons	10.0	3.7	11.1	.035	.01	.17	.11	.23	.59
50 gallons	10.0	2.6	7.8	.050	.02	.25	.17	.32	.86
14-row sprayer, tractor C, 2 men:									
15 gallons	6.7	5.0	17.6	.05	.01	.14	.07	.14	.42
25 gallons	11.2	5.0	17.6	.05	.01	.14	.07	.14	.43
35 gallons	15.7	5.0	17.6	.05	.01	.14	.08	.14	.45
50 gallons	22.0	4.9	17.2	.05	.02	.14	.09	.14	.51

[1] Sprayer repair costs are based on $1 per 1,000 gallons pumped. It is assumed pump is operating at full capacity all the time sprayer is in operation. Acres per hour are based on operating efficiency of 65 percent. Cost of water at 1/10 cent per gallon is included in total operating cost. Acres per hour based on 38-inch row spacing.

rates of application and cost of materials used may vary somewhat among growers. For this analysis, the following costs per acre are used:

	Cost per acre
First spraying, insecticide	$1.15
Second spraying, insecticide and fungicide	2.50
Third spraying, insecticide and fungicide	2.50
Fourth spraying, fungicide	1.35
Total	7.50

Table 17 shows combined costs of all the crop maintenance considered here. Selected costs from tables 14, 15, and 16 are used to illustrate estimated costs for the four sizes of potato growing operations. The 2-row cultivator and 12-row sprayer are used for the 80-acre production unit. The 4-row cultivator and 14-row sprayer are used for the larger acreages.

The costs shown in table 17 assume that only one 4-row cultivator is used. If the cultivator is operated 10 hours a day, 15 days would be required for the first cultivation and 10.4 days each for the second and third cultivation of the 640-acre unit. At least one operator in the Red River Valley is known to have cultivated 800 acres with one 4-row cultivator. However, weather conditions or other factors associated with the total farm enterprise may make it advisable to use two 4-row cultivators. If so, the cultivator fixed costs would be the same as for the 320-acre operation. The addition of another 4-row cultivator would increase equipment fixed costs by 17 cents per acre for the 640-acre unit.

TABLE 17.—*Combined fixed, operating (including labor), and materials costs per acre for potato crop maintenance*

Cost item	Costs based on—			
	80 acres	160 acres	320 acres	640 acres
Fixed costs of equipment	$3.67	$2.93	$1.46	$0.73
Operating costs:				
Harrowing	.28	.24	.24	.24
1st cultivation	1.30	.99	.99	.99
2d cultivation	1.07	.85	.85	.85
3d cultivation	1.07	.85	.85	.85
1st spraying	.47	.43	.43	.43
2d spraying	.59	.45	.45	.45
3d spraying	.86	.51	.51	.51
4th spraying	.86	.51	.51	.51
Spray materials	7.50	7.50	7.50	7.50
Total crop maintenance	17.67	15.26	13.79	13.06

Sprayer fixed costs shown in table 14 are charged entirely to the potato crop. If the sprayer is used for other crops, the fixed cost charged to potato production would be reduced. For example, the fixed costs for sprayer, tank, and pump for the 80-acre operation are $3 per acre (table 14). If this same sprayer is used on an additional 240 acres, the fixed cost charged to potato production would be reduced to $0.75 per acre and the total crop maintenance cost would be reduced from $17.67 to $15.42.

VINE REDUCTION COSTS

Occasionally, potato vines are killed by an early frost, but this cannot be relied upon, especially where acreages require several weeks to harvest. Vines may be killed either by the application of a herbicide or by mechanical means. The application of a chemical vine killer 2 weeks or more before harvest is a common practice. The killed and dried vines may, or may not, be subjected to mechanical vine reduction just before harvest. The application or omission of this treatment depends on the type of mechanical vine eliminator on the harvester, potato variety, and extent of vine growth.

Vine killer is applied with the same spraying equipment used for crop maintenance. Since the equipment fixed costs are charged to crop maintenance (table 17), operating costs plus the cost of the herbicide ($1.50 per acre) constitute the cost of vine killing. Using the same operating costs as shown for the third and fourth spraying in table 17, the costs per acre for chemical vine killing are as follows: $2.36 for an 80-acre operation and $2.01 for 160, 320, and 640 acres.

Mechanical vine reduction requires a special implement. Fixed costs for 2 sizes of machines are shown in table 18.

The operating costs of mechanical vine reducers are influenced by the vine density. A heavy vine growth requires more power than a lighter vine growth and consequently reduces the travel speed. In addition to power and labor costs, repairs constitute a substantial operating cost. Based on 2,000 hours of operating life, the total repair cost is estimated to be 150 percent of the new cost. This amounts to approximately 30 cents per acre, which is included in the total operating costs shown in table 19.

TABLE 18.—*Fixed costs of mechanical potato vine reducers based on expected life of 8 years*

Size of machine	Cost of new machine	Annual fixed cost	Cost per acre based on—			
			80 acres	160 acres	320 acres	640 acres
2-row	$830	$141	$1.76	$0.88	$0.44	$0.22
4-row	1,705	290	3.63	1.81	.91	.45

TABLE 19.—*Operating costs for mechanical potato vine reducers based on power requirements of 8.25 hp.-hr. per acre*

Size of vine reducer	Tractor	Speed (m.p.h.)	Acres per hour [1]	Cost per acre		
				Tractor	Labor	Total [2]
2-row	A	2.72	1.61	$0.90	$0.78	$1.98
2-row	B	3.62	2.13	.91	.59	1.80
2-row	C	4.61	2.72	.92	.46	1.68
2-row	D	5.00	2.95	1.06	.42	1.78
4-row	D	2.86	3.38	.92	.37	1.59
4-row	E	3.51	4.15	.90	.30	1.50

[1] Based on 38-inch row spacing and 77 percent operating efficiency.
[2] Total costs include $0.30 per acre for repairs.

POTATO HARVESTING COSTS

The potato harvester is generally the most costly single machine used by the potato grower. This machine is commercially available in models that differ widely, but all are designed to perform four essential functions: (1) Excavation, (2) elevation, (3) separation (including loose soil, clods, stones, and vines), and (4) conveyance to truck box. A power source is required to move the harvester and drive the mechanisms. The following types are currently used: Tractor drawn, with auxiliary engine; tractor drawn, with power takeoff (p.t.o.) drive; semimounted, with p.t.o. drive; tractor-mounted, with p.t.o. drive; or self-propelled.

As indicated earlier, it is not the purpose of this study to compare alternative systems of harvesting; nor is the purpose to compare different types of harvesters.

A harvester designed for one-man operation does not require both a tractor driver and a harvestor operator. Field conditions affect the number of pickers required on the harvester and also the harvesting rates (figs. 2 and 3). For these reasons, operating costs have been tabulated for varying harvesting rates and numbers of workers, which include tractor driver, harvester operator, and one truck driver.

FIGURE 2.—Harvesting with 2-row machine near Fort Myers, Fla., in exceptionally clean field. Only 2 pickers on harvester.

Field conditions that affect harvesting rates may be of a permanent nature, such as soil type and topography, or they may be seasonal, such as rainfall distribution. Because operating rates and pickers required on the harvester are widely variable, operating costs have been computed for a range of harvester performances.

The harvesting rate attainable with an individual harvester in the same field is subject to wide variations within a single harvest season. Soil moisture content is only one of the factors that affect harvesting rates. On certain soil types, large numbers of clods must be separated from potatoes if the soil is dry. This reduces the travel rate and requires more labor on the harvester for removing clods that the machine cannot handle. On the other hand, an excess of moisture reduces the capacity for separation of loose soil and thus imposes a limitation on the travel speed. With optimum soil moisture content, the harvesting rate can easily be double that attainable in the same field when the soil moisture content is either too low or too high.

Vine characteristics also affect harvester performance. Varietal differences and growing conditions contribute to the production of vines with characteristics that may affect the harvesting rate. If the tubers cling tenaciously to the vines, this can necessitate a reduction in travel speed and the addition of labor.

To prevent excessive mechanical injury to the tubers, prevailing field conditions and the relative susceptibility of the tubers to mechanical injury may make it necessary to limit travel speed to something less than that imposed by other limiting conditions. Harvesting rates have been calculated for speeds up to 4 m.p.h., but it is not to be implied that attainment of this speed is always in harmony with an acceptable amount of mechanical injury.

Fixed costs for potato harvesters are computed for an expected life of 8 years. On the basis of wear-out life, the harvester used on a small acreage would logically last many more years than one used on a large acreage each year. Obsolescence is also a factor; so, for the purpose of this analysis, it is assumed that the harvester will be replaced after 8 years of use.

The expense of repairs is a major operating cost for potato harvester operation and is widely variable, depending upon the soil type. The abrasiveness of the soil is an extremely important factor affecting repair costs, particularly replacement of primary aprons and sprockets. The primary apron life, in terms of total acreage, may vary from as low as 60 acres in very abrasive soil to more than 1,600 acres on a marl soil, such as that in Dade

FIGURE 3.—Harvesting with 2-row harvester in field 2 miles from field in figure 2. Eleven pickers were on this harvester, and it was stopped much of the time. This field was extremely weedy and the plant material left by the mechanical vine reducer prevented soil sifting through the aprons. This picture and figure 2 illustrate the contrasting field conditions that determine the number of pickers required.

County, Fla. It is obvious that any figure used for cost of repairs would not be universally applicable. However, some estimate of repair and maintenance cost is required and $2 per acre is the figure that is used. This amount is close to the average estimated cost of $1.70 per acre as determined by Maier and Loftsgard (*5*) from information supplied by 82 growers in the Red River Valley.

In addition to the harvester, the potato harvesting operation requires at least 3 hopper-bottom truck boxes, 3 trucks, and a tractor. If the harvester is a self-propelled machine, a tractor is not required. Elimination of the tractor would not be a net cost reduction, however, because another power source must be substituted. Since it is not our intent to compare different systems of potato harvesting, or different types of machines, this analysis will be confined to harvesting with a 2-row harvester and a tractor. No differentiation is made of whether it is pulled, tractor-mounted, or semi-mounted.

Commercial potato harvesters are available in makes and models that span a relatively wide range in prices. Fixed costs are computed for harvesters ranging in price from $6,000 to $12,000. In general, the more complex (and consequently more costly) machines are designed to cope with a wider variety of adverse field conditions than the simpler, lower cost harvesters.

The annual fixed costs and costs per acre for harvesters are shown in table 20. Depreciation cost, which is based on a life of 8 years, plus interest, housing, taxes, and insurance amount to $170.30 per $1,000 of new cost. Fixed costs per acre, using other harvester prices and acreages than those shown, can be readily computed by multiplying the harvester cost by $0.1703 and dividing by the number of acres harvested annually.

Operating costs for harvesting include $2 per acre for the harvester repairs, $2.90 per hour for one truck, $2.50 per hour for a tractor, and a wage rate of $1.25 per hour. Three or more trucks are required for receiving potatoes from the harvester and transporting them to the storage. However,

TABLE 20.—*Fixed costs of potato harvesters and hopper-bottom truck box*

Cost of new machine	Annual fixed cost	Fixed cost per acre based on—			
		80 acres	160 acres	320 acres	640 acres
$6,000	$1,021.80	$12.77	$6.38	$3.19	$1.60
$7,000	1,192.10	14.90	7.45	3.72	1.86
$8,000	1,362.40	17.02	8.51	4.25	2.13
$9,000	1,532.70	19.15	9.57	4.79	2.39
$10,000	1,703.00	21.29	10.64	5.32	2.66
$11,000	1,873.30	23.41	11.70	5.85	2.93
$12,000	2,043.60	25.54	12.77	6.38	3.19
$700 [1]	103.46	1.49	.74	.37	.19

[1] Hopper-bottom truck box of 120 cwt. capacity; based on 8 years' expected life.

since only one truck at a time is used in the harvesting operation, the cost of additional trucks are assigned to transportation costs. Transportation costs are obviously related to the distance from the field to the storage. The cost per acre for trucking is also closely related to yield. Maier and Loftsgard (*5*) found the average cost of trucking for 82 growers in 1960 to be $7.20 per acre. The average yield was 145 cwt. per acre.

With the exception of maintenance and repair costs of the harvester ($2 per acre), other costs are inversely proportional to the harvesting rate. The harvesting rate is determined by the travel speed, row spacing, and operating efficiency. Since the row spacing is established when the crop is planted, travel speed and operating efficiency are the variables that determine the harvesting rate. If we assume that the available power is not a limiting factor, the attainable travel speed is limited by the soil separating capacity of the aprons, the ability of the workers to remove foreign material, or the mechanical injury to the potatoes from excessive speed. Prevailing field conditions affect all three of these factors. For the purpose of this study, it is assumed that excessive tuber injury will result from travel speed in excess of 4 m.p.h.

The operating efficiency is subject to more variation in the harvesting operation than in any other field operation in the production of the potato crop. Length of the rows, time used to turn, and time used for making adjustments or repairs in the field contribute to reduction of operating efficiency. Table 21 shows the relationship of performance (acres per hour) to travel speed and operating efficiency. The total cost per acre is the sum of fixed and operating costs. This is arrived at by combining appropriate figures from tables 20 and 23. For instance, if a harvester costing $11,000 is used on 320 acres per year, the fixed cost per acre is shown to be $5.85. At least three hopper-bottom truck boxes would be required, which would add $1.11, making total fixed cost of $6.96 per acre. If the average harvesting rate is 1.2 acres per hour, using a total of 6 workers, the operating cost per acre is found in table 23 to be $12.74. The total cost per acre for harvesting is $12.74 + $6.96, or $19.70. The cost per cwt. is obviously $19.70 divided by the yield. With a yield of 210 cwt. per acre, the harvesting cost per cwt. would be 9.4 cents. This harvesting rate is not remarkable. Table 22 shows the harvesting rate in acres per hour as related to yield in cwt. per acre and truckloads per day.

TABLE 21.—*Relation of acreage of potatoes harvested per hour to travel speed and operating efficiency of tractor* [1]

Acres harvested per hour	Travel speed (m.p.h.) of harvester operating at efficiency of—				
	60 percent [2]	70 percent [2]	80 percent [2]	90 percent [2]	100 percent
0.6	1.30	1.11	0.97	0.87	0.78
0.7	1.51	1.30	1.13	1.01	.91
0.8	1.73	1.48	1.30	1.15	1.04
0.9	1.95	1.67	1.46	1.30	1.17
1.0	2.17	1.86	1.62	1.44	1.30
1.2	2.60	2.23	1.95	1.73	1.56
1.4	3.03	2.60	2.27	2.02	1.82
1.6	3.47	2.97	2.60	2.31	2.08
1.8	3.90	3.34	2.92	2.60	2.34
2.0	4.33	3.71	3.25	2.89	2.60
2.2	4.76	4.08	3.57	3.17	2.86
2.4	5.20	4.45	3.90	3.47	3.12
2 6	5.63	4.83	4.22	3.75	3.38
2.8	6.06	5.20	4.55	4.04	3.64

[1] Tractor transmission gear ratios determine travel speeds. Indicated speeds would seldom be precisely attained. These travel speeds were calculated in conjunction with operating efficiencies to obtain acres per hour increments that coincide with acres per hour values in other tables.

[2] Speeds below horizontal lines are considered impractical because of excessive injury.

TABLE 22.—*Truckloads (120 cwt.) of potatoes harvested in 10-hour day at specified harvesting rates and yields per acre*

Acres harvested per hour	Truckloads when yield per acre is—[1] 100 cwt.	120 cwt.	145 cwt.	175 cwt.	210 cwt.	250 cwt.	300 cwt.	360 cwt.
0.7	5.8	7.0	8.5	10.2	12.2	14.6	17.5	21.0
0.8	6.7	8.0	9.7	11.7	14.0	16.7	20.0	24.0
0.9	7.5	9.0	10.9	13.1	15.7	18.7	22.5	27.0
1.0	8.3	10.0	12.1	14.6	17.5	20.8	25.0	30.0
1.2	10.0	12.0	14.5	17.5	21.0	25.0	30.0	36.0
1.4	11.7	14.0	16.9	20.4	24.5	29.2	35.0	42.0
1.6	13.3	16.0	19.3	23.3	28.0	33.3	40.0	48.0
1.8	15.0	18.0	21.7	26.2	31.5	37.5	45.0	54.0
2.0	16.6	20.0	24.2	29.2	35.0	41.7	50.0	60.0
2.2	18.3	22.0	26.6	32.1	38.5	45.8	55.0	66.0
2.4	20.0	24.0	29.0	35.0	42.0	50.0	60.0	72.0

[1] Harvesting rates below horizontal lines could not be attained in practice because of limitation of apron capacity of harvester.

TABLE 23.—*Operating cost per acre for harvesting potatoes*

Acres harvested per hour	Cost per acre [1] Tractor	Truck	Labor per worker	Total operating cost per acre [2] 3 workers	4 workers	5 workers	6 workers	7 workers	8 workers
0.7	$3.56	$4.14	$1.79	$15.07	$16.86	$18.65	$20.44	$22.23	$24.02
0.8	3.12	3.62	1.56	13.42	14.98	16.54	18.10	19.66	21.22
0.9	2.77	3.22	1.39	12.16	13.55	14.94	16.33	17.72	19.11
1.0	2.50	2.90	1.25	11.15	12.40	13.65	14.90	16.15	17.40
1.2	2.08	2.42	1.04	9.62	10.66	11.70	12.74	13.78	14.82
1.4	1.77	2.08	.90	8.55	9.45	10.35	11.25	12.15	13.05
1.6	1.56	1.81	.78	7.71	8.49	9.27	10.05	10.83	11.61
1.8	1.39	1.61	.70	7.09	7.79	8.50	9.19	9.89	10.59
2.0	1.25	1.45	.62	6.56	7.18	7.80	8.42	9.04	9.66
2.2	1.14	1.32	.57	6.17	6.74	7.31	7.88	8.45	9.02
2.4	1.04	1.21	.52	5.81	6.33	6.85	7.37	7.89	8.41

[1] Size C tractor at $2.50 per hour; truck at $2.90 per hour; labor, $1.25 per hour.
[2] Includes tractor and truck costs, labor costs for specified number of workers (including truck and tractor drivers), and $2 per acre for harvester repairs.

The performance rate for any row spacing or effective machine width can be calculated by the formula:

$$C=\frac{SWE}{825}$$

where:

C= capacity in acres per hour
S= travel speed in miles per hour
W= effective machine width in feet
E= percent operating efficiency

The cost of various crop production operations are reasonably predictable and are entirely independent of the resulting yield. The per-acre operating cost for harvesting, on the other hand, is closely related to yield if the carrying capacity of the harvester aprons limits travel speed. If this is the case, the operating cost per cwt. is, within certain limits, independent of the yield, but total harvesting cost per cwt. is reduced by increased yields, because fixed cost of the harvester per cwt. is reduced. Table 23 shows the operating cost per acre as related to acres per hour with 3 to 8 workers (including tractor and truck drivers, and harvester operator). Table 24 shows the interactions of selected yields, harvesting rates, labor, and annual acreage, as related to potato harvesting costs per acre and per cwt.

TABLE 24.—*Relation of operating and total harvesting costs per acre and per hundredweight of potatoes to yield, harvesting rate, and labor*

Yield per acre, operating efficiency, and travel speed	Acres harvested per hour	Truckloads per day	Operating cost				Total harvesting cost per cwt. based on—[1]							
			Per acre		Per cwt.		80 acres		160 acres		320 acres		640 acres	
			4 workers	8 workers	4 workers	8 workers	4 workers	8 workers	4 workers	8 workers	4 workers	8 workers	4 workers	8 workers
250 cwt.:														
70%, 2.97 m.p.h.	1.6	33.3	$8.49	$11.61	$0.034	$0.047	$0.145	$0.158	$0.90	$0.103	$0.061	$0.074	$0.048	$0.061
60%, 1.51 m.p.h.	.7	14.6	--------	24.02	--------	.096	--------	.207	--------	.152	--------	.124	--------	.110
210 cwt.:														
70%, 3.34 m.p.h.	1.8	31.5	7.79	10.59	.037	.050	.170	.183	.103	.116	.070	.083	.054	.062
60%, 2.60 m.p.h.	1.2	21.0	--------	14.82	--------	.071	--------	.203	--------	.137	--------	.104	--------	.087
60%, 1.51 m.p.h.	.7	12.2	--------	24.02	--------	.114	--------	.247	--------	.181	--------	.148	--------	.131
145 cwt.:														
70%, 4.08 m.p.h.	2.2	26.6	6.74	9.02	.046	.062	.238	.254	.142	.158	.094	.110	.071	.087
60%, 1.73 m.p.h.	.8	9.7	--------	21.22	--------	.146	--------	.339	--------	.242	--------	.194	--------	.170
100 cwt.:														
70%, 4.08 m.p.h.	2.2	18.3	6.74	--------	.067	--------	.346	--------	.207	--------	.137	--------	.102	--------
60%, 2.60 m.p.h.	1.2	10.0	--------	14.82	--------	.148	--------	.427	--------	.287	--------	.217	--------	.183

[1] Fixed costs per acre based on $11,000 harvester and three $700 hopper-bottom truck boxes:
80 acres per year $27.88
160 acres per year 13.92
320 acres per year 6.96
640 acres per year 3.50

TOTAL COST OF POTATO PRODUCTION AND HARVESTING

Selected values from tables 2 through 24 may be added together in an almost infinite number of combinations to arrive at total cost figures. For convenience in developing a figure for total cost, the worksheets in figures 4 and 5 may be completed with selected values from these tables.

WORK SHEET FOR SUMMARIZING POTATO HARVESTING COSTS

1. Annual acreage
2. Yield (cwt./acre)
3. Harvesting rate (cwt./hour)
4. Acres/hour (line 3÷line 2)

Operating Costs

5. Labor ($/hour)
6. Tractor ($/hour)
7. Truck ($/hour)
8. Sum of lines 5, 6, and 7
9. Harvester repair cost ($/acre)
10. Total operating cost per acre (line 8÷line 4+line 9)
11. Total operating cost per cwt. (line 10÷line 2)

Fixed Costs

12. Price of new harvester plus hopper-bottom boxes
13. Annual cost (line 12×0.17)
14. Cost per acre (line 12÷line 1)
15. Cost per cwt. (line 14÷line 2)

Total Harvesting Costs

$ per acre (line 10÷line 14)

$ per cwt. (line 11÷line 15)

FIGURE 4

WORK SHEET FOR SUMMARIZING TOTAL POTATO PRODUCTION AND HARVESTING COSTS

1. Annual acreage________________

2. Land rent________________

3. Seed potato cost________________

    Fertilizer________________

4. Plowing (table 9)________________

5. Secondary preplanting tillage (tables 10 and 11)________________

6. Seed potato cutting (tables 12 and 13)________________

7. Potato planting (tables 14 and 15)________________

8. Crop maintenance (tables 16, 17, 18, and 19)________________

9. Vine reduction (tables 19, 20, and 21)________________

10. Harvesting (table 26)________________

11. Total cost ($/acre)________________

12. Cost per cwt. (line 11÷cwt. per acre)________________

Figure 5

TRANSPORTATION, HANDLING INTO AND OUT OF STORAGE, STORAGE, AND SHRINKAGE

The preceding analysis covers cost factors of production through harvesting to the point where the potatoes are deposited by the harvester into the hopper-bottom truck box. Further important costs are unavoidable before the crop is in shape to market.

It is not within the scope of this publication to analyze these costs, but those for transportation, handling into storage, storage, handling out of storage, and shrinkage are considerable and must be taken into consideration in determining a break-even market price.

Since management and supervision require time and ability, it is logical to add a charge for these functions in arriving at the market price required for a profitable enterprise.

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